500 MINIMUM DESIGN CRITERIA

500.01 General

1. All street, alley, sidewalk, and bikeway systems will comply with these specifications, the State Specifications where applicable, and with the approved plans. Sidewalks and curb ramps shall comply with most recent ADA accessibility requirements, including but not limited to, truncated domes (see Detail 500-17).

2. Street layout, alignment, and classification shall conform with the Town of Frederick Subdivision Regulations and the Comprehensive Plan.

3. Consideration shall be given, within the established framework of local streets, to provide for uniformity of street widths, proper alignment, and conformity to existing street patterns. The street design shall be directly related to the traffic needs. The streets, intersections, driveways, and pedestrian facilities shall be designed to provide for the greatest safety for both pedestrians and motorists.

4. All alleys shall be concrete and provide paved access to a paved street at both ends (see Detail 500-06).

5. In situations where redevelopment occurs along an existing unpaved alley, and utilizes the alley as a primary access, the Developer shall be responsible for paving the alley along the frontage of the property, and extending the paving to the closest intersection of the alley with a public street.

6. Transportation Impact Studies are required in order to adequately assess the impacts of a development proposal on the existing and/or planned street system. Unless waived by the Town Engineer, a written Transportation Impact Study will be required for all development proposals when trip generation is expected to exceed 50 vehicles during the peak hour or 500 Average Daily Traffic (ADT), or in the case where a localized safety or capacity deficiency exists as determined by the Town Engineer. Roadway improvements are based upon the traffic projections shown in the approved Traffic Study and the CDOT Access Code.

7. All developments shall provide access in accordance with the requirements of the Town of Frederick Land Use Code and the Colorado Department of Transportation Access Code for intersection spacing.

8. Unless waived by the Town Engineer in writing, a Pavement Design Report conforming to the Standards set forth in this Section is required for all roadway construction.

9. Streets of less than the entire right-of-way and pavement width are not permitted, unless approved in writing by the Town Engineer.

10. All roundabouts shall adhere to the standards and recommendations contained in the FHWA publication *Roundabouts: An Informational Guide, FHWA-RD-00-067*.

501 RIGHT OF WAYS AND STREET CROSS-SECTIONS

501.01 General

1. Sufficient right-of-way will be provided as required for the traffic needs and cross-section and maintenance of the street including cut or fill slopes, auxiliary lanes, sidewalks, public landscaping, signing, utilities, and other aspects of the development. The right-of-way will extend a minimum of 6 inches beyond the back of the detached sidewalk.

2. Standard right-of-way and street widths shall meet or exceed the minimums set forth in the Design Criteria. Additional right-of-way and roadway width may be required to accommodate traffic or other development needs such as turn lanes, accel/decel lanes, extra lanes, pedestrian or bicycle facilities, landscaping, utilities, or construction requirements such as cut or fill slopes.

3. Except at intersections or where superelevation is required, all roadways shall have a minimum 2 percent crown. Parabolic or curved crowns are not allowed. In no case shall the pavement cross slope at warped intersections exceed the grade of the through street.

501.02 Design Criteria (Straight Zoning)

Standard right-of-way and street widths shall meet or exceed the following minimum criteria:

Table 500-01 - Minimum ROW and Roadway Width

STREET TYPE	LAND USE	DESIGN ADT	MINIMUM WIDTH RIGHT-OF-WAY	MINIMUM FLOWLINE WIDTH ROADWAY
Major Arterial	Weld County Road 7, 11, 13, 20	9000+	120ô	76'
Arterial (2)	All	9000+	100ô	72'
Collector (2)	All	1,000 -9,000	75'	48'
Local	Commercial/Industrial	0 - 2,500	64ô	40ô
Local	Residential Standard	300 - 1,000	60ô	34ô
Alley	All	N/A	20ô	15'
Emergency Access	All	N/A	20ô	20ô

Notes:

1. In all cases where traffic volumes are anticipated to exceed the design average daily traffic (ADT) shown above, the street and right-of-way width will be increased to the next higher classification, or increased in accordance with the specific design needs of the proposed street.

2. Because of the wide range of volumes and uses that can be experienced with arterial and collector streets, the Town Engineer will review on a case by case basis to determine the actual right-of-way and street width needs.

3. The above table assumes the typical street cross-sections. See details at the end of this section.

501.03 Design Criteria (Planned Unit Developments)

1. The streets shall be designed in conjunction with the overall intent of the PUD. The following requirements will apply:
   a. The design of all streets shall at a minimum meet the typical cross-collections shown on Details 500-01 through 500-06 and Table 500-01.
   b. On local residential streets, travel lanes shall be a minimum of ten feet (10') in width, exclusive of curb and gutter.
   c. Not providing for on-street parking in the design of the street section requires the written approval of the Town. In determining whether approval will be granted, the Town shall consider what measures the Developer has taken to eliminate the need for on-street parking.
   d. Sufficient right-of-way width shall be provided as required for the traffic needs and cross-section and maintenance of the street including cut or fill slopes, auxiliary lanes, sidewalks, public landscaping, signing, utilities, and other aspects of the development. Unless otherwise approved, right-of-way will extend a minimum of 0.50' beyond the back of the sidewalk.

502 HORIZONTAL ALIGNMENT

502.01 General

1. Horizontal alignment shall provide for the safety of pedestrians, bicyclists, and motorists.

2. The street pattern in a subdivision shall be the most advantageous configuration to serve adjoining areas and the entire neighborhood or district. Where appropriate to the design, proposed streets shall be continuous and in alignment with existing, planned or platted streets.

3. Proposed streets shall be extended to the boundary lines of the subdivision, except where prohibited by topography or other physical conditions, or where the Town Engineer deems such extension is not necessary for connection to adjacent properties. Where streets will be extended beyond the property line, sufficient engineering data shall be provided to establish feasibility of extension meeting all

Town standards. Construction of the proposed streets may include grading and drainage transitions at the edge of the development.

4. Streets shall be placed in accordance with the Town of Frederick Land Use Code where applicable.

5. Spiral curves may be used in the design of arterial roadways only with written approval of the Town Engineer.

6. Sharp horizontal curves at or near the top of pronounced crest or bottom of vertical curves should be avoided.

502.02 Handicap Ramps

Handicap ramps with truncated domes are required at all intersections. Four (4) at cross intersections and three (3) at all Tee intersections (see Detail 500-17).

502.03 Design Criteria

1. All proposed streets shall conform with the horizontal curve standards outlined as follows:

Table 500-02 - Minimum Horizontal Roadway Curves

STREET TYPE (DESIGN SPEED)	MINIMUM CENTERLINE RADIUS (FT.)	MINIMUM TANGENT BETWEEN REVERSE CURVES (FT.)
Arterial / Major Arterial (Design Speed 50 / 55 mph)	955	300
Collector (Design Speed 40 mph)	650	150
Local Industrial (Design Speed 35 mph)	475	100
Local Commercial (Design Speed 35 mph)	475	100
Local Residential Standard (Design Speed 35 mph)	475	100
Alley (20 mph)	90	---
Emergency Access	---	---
Truck Route	---	---

a. Reversing curves are only allowed in the Town of Frederick with written approval from the Town Engineer.
b. These horizontal curve standards are for the design speeds shown

assuming 4% superelevation for arterial streets and no superelevation on collector or local streets. The Town may require curves designed for higher design speeds as conditions require.

c. Where curves are designed with superelevation, the superelevation shall be in accordance with the recommendations of A.A.S.H.T.O. and approved by the Town. The rate of superelevation, the superelevation runout length, the crown runout length, and the point at which the full superelevation is reached shall be clearly shown on the construction plans. Superelevation is not permitted on collector or local streets.

d. A.A.S.H.T.O. stopping sight distances must be maintained at all times. These horizontal curve standards are for situations where there will be adequate stopping sight distance on the curve. In areas where obstructions limit sight distance, curve lengths may need to be greater than listed.

2. There shall be a minimum tangent where a curvilinear street is approaching an intersection. This distance shall be a minimum of 150' for a collector street approaching an arterial street. The minimum tangent distance for local street intersections and a local street approaching a collector street shall be 100'.

3. Curb radii shall conform with the following table:

Table 500-03 - Minimum Flowline Radius

Through Street	Intersecting Street		
	Minor/Major Arterial	Collector	Local
Arterial / Major Arterial	50	30	25
Collector	30	25	20
Local	25	20	15

a. All curb returns shall have a minimum slope of 1.0% and a maximum of 3.0%. If the curb return includes a handicap ramp the cross slope must conform with all ADA requirements.

503 VERTICAL ALIGNMENT

503.01 General

1. Vertical alignment and grades shall take into consideration the existing topography, drainage needs, and shall provide for the safety of pedestrians and motorists. Unless modified in these Standards, vertical alignment shall be designed in accordance with A.A.S.H.T.O. criteria.

2. Continuous changing of grades that create a "roller coaster" effect shall not be permitted.

503.02 Design Criteria

1. All proposed streets shall conform with the minimum and maximum allowable grade standards shown in the following table:

Table 500-04 - Minimum and Maximum Grades for Roadways		
STREET	**LAND**	**Min/Max % GRADE**
Arterial/Major Arterial	All	0.5/5.0
Collector	All	0.5/5.0
Local	Industrial/Commercial	0.5/5.0
Local	Residential Standard	0.5/5.0
Cul-de-sacs	Residential	1.0/5.0
Alley	All	0.5/5.0

* All Fire/Ambulance access shall conform to the Frederick-Firestone Fire Protection District Standards.

** The maximum grades shall only be used in extreme topographic conditions.

2. Connections with existing streets shall be made in a way that will create a smooth transition. Connection with existing roadways shall be smooth transitions conforming to normal vertical curve criteria if the algebraic difference in grade between the existing and proposed grade exceeds eight-tenths (0.008 ft./ft.) of a percent. When a vertical curve is used to make this transition, it shall be fully accomplished prior to the connection with the existing improvements and shall also comply with the grade requirements at intersection approaches.

3. Existing grade shall be shown for at 300 feet with field verified as-builts showing stations and elevations at 25 foot intervals. In the case of connection with an existing intersection, these as-builts are to be shown within a 300 foot radius of the intersection. This information will be included in the plan and profile that shows that proposed roadway. Limits and characteristics of the proposed improvement are the primary concern in the plan view. Such characteristics include horizontal alignment, off-site intersections, limits of the improvement, etc.

4. Previously approved designs for the proposed improvement are not an acceptable means of establishing existing grades. However, they are to be referenced on the construction plan where they occur.

5. The basis of the as-built elevations shall be the design elevations (both flowline or both top of curbs, etc.) when possible.

6. The higher volume street at an intersection shall govern the through grade, and cross-sections. The maximum allowable approach grade at the intersection of two arterials is 2%. At all other intersections the maximum approach grade shall be 3%. In both cases the maximum grade shall be designed with a minimum distance as designated by the following table:

Table 500-05 - Maximum Grade Approach Lengths at Intersections			
APPROACHING STREET	**LOCAL**	**COLLECTOR**	**ARTERIAL**
Local	50 feet	50 feet	75 feet
Collector	----	75 feet	150 feet
Arterial	----	----	200 feet

Notes:

a. Distances shown are measured from the flowline intersections.

b. All private commercial driveways shall follow all of the standards for local roadways.

c. If design constraints will not allow the minimum length of the maximum grade or the maximum grade to be achieved, the type of access and access control will be as directed by the Town Engineer.

d. In intersections where there will be crosspans, the transition of the crown into the crosspan shall occur in fifty feet (50') for areas where the approach grade is between 2% - 3%. The transition of the crown in the crosspan shall occur in thirty-five feet (35') for streets where the approach grade is less than 2%. There shall be no crosspans on collector and arterial streets. Unless otherwise approved by the Town, there shall be no crosspans on local streets with an average daily traffic volume greater than 500 other than at stop conditions. The use of grade breaks in lieu of vertical curves is discouraged. However, if a grade break is necessary and the algebraic difference in grade does not exceed 0.008 ft/ft, the grade break will be permitted. The maximum grade allowed at the point of tangency at a curb return for local and collector roadways shall be 2.0% and for arterial roadways a maximum of 1.0%.

7. Crest vertical curves shall comply with the following criteria:

Table 500-06 - Minimum Length of Crest Vertical Curves			
Change In % Grade	**Arterial (50 / 55 mph)**	**Collector (40 mph)**	**Other (35 mph or less)**
0.00 ï 0.80	None	None	None
1.00 ï 2.00	320ô	160ô	90ô
2.00 ï 3.00	480ô	240ô	90ô
3.00 ï 4.00	640ô	320ô	120ô
4.00 ï 5.00	800ô	400ô	150ô
5.00 ï 6.00	960ô	480ô	180ô
6.00 ï 7.00	1,120ô	560ô	210ô
7.00 ï 8.00	1,280ô	440ô	240ô
8.00 ï 9.00	----	720ô	270ô
9.00 ï 10.00	----	800ô	300ô

a. Lengths above do not allow passing on crest of vertical curves. Design may

warrant a passing move on collectors or arterials, which would lengthen the vertical curves. The required lengths for passing will be provided on a case by case basis by the Town.

b. These vertical curve lengths are for the design speeds as shown. The Town may require curves designed for different design speeds as conditions require.

c. All vertical curves shall be labeled in the profile with the length, K value, VPC, VPT, VPI, low point and high point along with the station an elevation of these components.

d. All vertical curves shall conform with A.A.S.H.T.O. requirements.

8. Sag vertical curves shall comply with the following criteria:

Table 500-07 - Minimum Length of Sag Vertical Curves			
Change In % Grade	**Arterial (50 / 55 mph)**	**Collector (40 mph)**	**Other (35 mph or less)**
0.00 ï 1.00	None	None	None
1.00 ï 2.00	220'	140'	90'
2.00 ï 3.00	330'	210'	120'
3.00 ï 4.00	440'	280'	160'
4.00 ï 5.00	550'	350'	200'
5.00 ï 6.00	660'	420'	240'
6.00 ï 7.00	770'	490'	280'
7.00 ï 8.00	880'	560'	320'
8.00 ï 9.00	----	630'	360'
9.00 ï 10.00	----	700'	400'

a. These vertical curve lengths are for the design speeds as shown. The Town may require curves designed for different design speeds as conditions require.

504 INTERSECTIONS

504.01 General

1. Intersections (which shall include all street access points - both public and private) shall be designed to provide for the safety of pedestrians and motorists.

2. At street intersections, property lines shall be truncated as shown in the details at the end of this section to provide adequate right-of-way for curb ramps, utilities, and site distance triangles.

3. Intersection design shall take into consideration auxiliary turn lanes as required by the approved Transportation Impact Study, or as required for site specific conditions, as determined by the Town Engineer.

4. Intersection spacing shall be in accordance with the CDOT Access Code, latest

edition.

5. All proposed intersections shall be at right angles unless topography and other limiting factors of good design and safety otherwise require. No intersection shall be at an angle of less than 75 degrees.

6. The higher volume street at an intersection shall govern the through grade. In the case of two intersecting streets with the same classification, the Town Engineer may determine the through street.

7. The elevation at the PCR of the curb return on the through street is always set by the grade of the through street in conjunction with the pavement cross slope.

8. Carrying the crown of a side street into the through street is permitted only when drainage considerations warrant such design.

9. A more detailed review will be performed on the intersection of two arterial roadways to maximize drivability.

10. All intersections requiring a traffic signal shall include Opticom sensors for emergency vehicles. The Opticoms shall be Model Number 722 Optical Detector and 754 Phase Selector manufactured by 3M unless otherwise directed by the Frederick-Firestone Fire Protection District or the Town of Frederick Police Department.

504.02 Design Criteria

1. The design criteria for all street intersections shall conform with the Horizontal Alignment Design Criteria outlined in this document.

2. All intersections shall be designed and constructed with pedestrian curb ramp access on all corners. Curb ramps shall conform with ADA standards.

3. The major considerations in alignment design are safety, grade, profile, road area, design speed, sight distance, topography, drainage, and performance of heavy-duty vehicles. The road alignment should provide for safe and continuous operation at a uniform design speed. New road layout shall bear a logical relationship to existing or platted roads in adjacent properties.

   Adequate intersection design necessitates the provision of safe ingress and egress from one street or driveway to the other, based in part on the ability of a driver to see oncoming vehicles or pedestrians. The following guidelines shall be used in the design of intersections, private driveways and public streets which intersect other traffic carrying facilities.

   ***Sight Distance Triangle*:**
   At the intersection of two public streets or a private driveway and a public street, sight distance shall be evaluated across a ñsight distance triangleò where obstructions are restricted according to the following criteria. Within the area of the triangle there must be no wall, fence, sign, foliage, berm, or other structure that will

obscure the driverôs view of traffic approaching that intersection. The structures or berms within the sight distance triangle can extend no higher than 24 inches above the curb elevation and no lower than eight feet above the curb. Exceptions to this requirement exist for public facilities such as fire hydrants, utility poles and traffic control devices. These facilities must be located to minimize visual obstruction.

The sight distance triangles are formed by lines plotted along the edge of the traveled way of both the major and minor roads and the diagonal lines that connect the other ends of those lines as shown in Figure 500-01. Distance d1 is measured to vehicles approaching from the right and d2 is measured to vehicles approaching from the left. The sight lines (d1 & d2) have their origin at the stopped driverôs eye, 14.5 feet behind the edge of the traveled way.

Tables 500-8 and 500-09 show recommended sight distances d1 & d2 for passenger vehicles and semi-tractor trailer trucks for several different vehicle operating speeds. For complex roadway configurations, road grades exceeding 3% or skewed intersections refer to *AASHTO - A Policy on Geometric Design of Highways and Streets* latest edition. The tables were developed according to the following general criteria:

a. Vehicles turning left or right can accelerate to the operating speed of the intersecting street without causing approaching vehicles to reduce speed by more than 70 percent of their initial speed.
b. Vehicles turning left can clear the near half of the street without conflicting with vehicles approaching from the left.
c. The distance requirements are based on the driverôs eye being 3.5 feet above the roadway and an object height of 3.5 feet. For semi-tractor trailers, a 6.0 foot driverôs eye height and a 3.5 feet object height are assumed.
d. The operating speed on each approach is assumed to be (in the order of desirability):
    1) The 85th percentile speed;
    2) The speed limit, if based on a traffic engineering study;
    3) The design speed in the case of a new facility.

4. Determination of need for traffic control devices, including stop signs and traffic signals shall be made by the Town in accordance with the MUTCD and other applicable Town regulations.

5. When the criteria for sight distance cannot be met, the Town may prohibit certain turns by exiting vehicles to provide safe operating conditions. These standards apply to accesses on State Highways and Town streets.

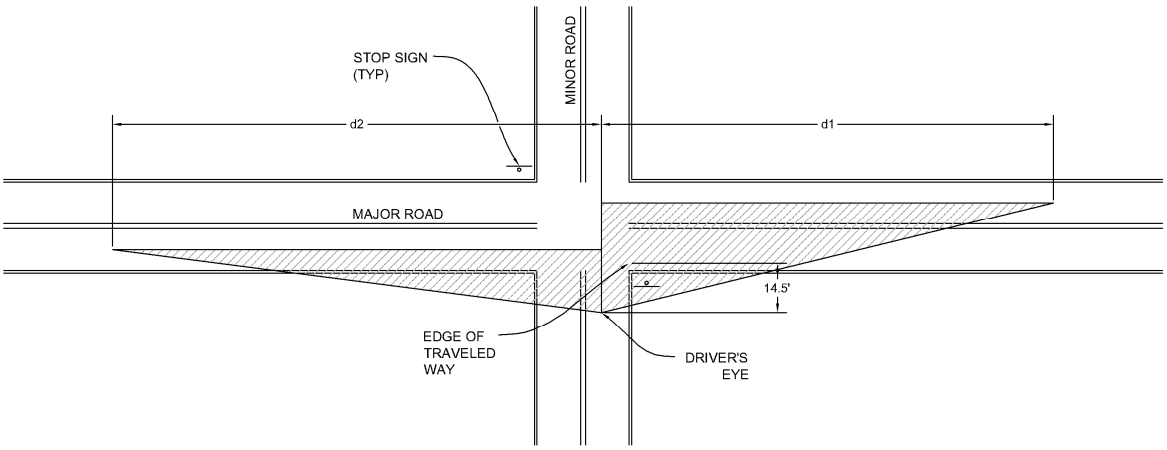

FIGURE 500-01
SIGHT TRIANGLES

Table 500-08 - Sight Distance for Passenger Cars Exiting from Private Access or Public Streets onto Two-Lane Roads		
Speed (Mph)	**Safe Sight Distance, d^1**	**Safe Sight Distance, d^2**
20	225ô	195ô
25	280ô	240ô
30	335ô	290ô
35	390ô	335ô
40	445ô	385ô
45	500ô	430ô
50	555ô	480ô
55	610ô	530ô
60	665ô	575ô

Table 500-09 - Sight Distance for Semi-Trailers Exiting from Private Access or Public Streets onto Two-Lane Roads		
Speed (Mph)	**Safe Sight Distance, d[1]**	**Safe Sight Distance, d[2]**
20	345ô	315ô
25	430ô	390ô
30	515ô	470ô
35	600ô	545ô
40	685ô	625ô
45	770ô	695ô
50	855ô	780ô
55	940ô	860ô
60	1020ô	930ô

504.03 Spacing Criteria

All intersection spacing shall meet or exceed the criteria set forth in the CDOT Access Code, latest edition.

504.04 Auxiliary Lanes

1. The need for auxiliary lanes shall be determined from the approved Traffic Impact Study. The Town Engineer reserves the right to require auxiliary lanes where the Town deems it necessary to improve public safety and or traffic flow.

2. All auxiliary lanes shall meet or exceed the standards in the A.A.S.H.T.O. ñA Policy on Geometric Design of Highways and Streetsò, latest edition (also called the *Green Book*).

505 CUL-DE-SACS

505.01 General

1. All cul-de-sacs shall meet the requirements of the Frederick-Firestone Fire Protection District.

2. Permanent dead-end streets shall be in the form of a cul-de-sac. Dead-end streets without a cul-de-sac shall not be allowed unless designed to connect with a future street and only with written approval of the Town Engineer.

3. The maximum length of the cul-de-sac as measured along and between the radius point and the right-of-way line on the abutting street shall be 500 feet or a maximum of 15 residential dwelling units, whichever is greater.

505.02 Design Criteria

1. All cul-de-sacs shall have a minimum flowline radius of fifty (50) feet.

2. Sufficient right-of-way will be provided as required for the traffic needs and cross-section and maintenance of the cul-de-sac including cut or fill slopes, auxiliary lanes, sidewalks, public landscaping, signing, utilities, and other aspects of the development.

3. Cul-de-sacs which have internal islands shall be subject to review and approval by the Frederick-Firestone Fire Protection District and Town of Frederick. In general, the circulation aisle between the island and the exterior curb shall have a 50' outside radius and a 30' inside radius. There shall be no parking within these circulation aisles.

4. Where cul-de-sacs have internal islands with irrigated landscaping, adequate design measures shall be made to drain the landscaped area to avoid damage to the adjacent pavement.

5. All other design criteria shall be the based on the design criteria for the particular street classification.

506 STRUCTURAL CROSS-SECTION

506.01 General

1. The purpose of this section is to present the pavement design criteria required for use on all streets and public parking areas in the Town of Frederick. Private improvements requiring approval by the Town and serving three or more dwelling units shall also comply with these Standards unless otherwise waived by the Town Engineer in writing.

2, The top lift of pavement is required before Conditional Acceptance will be granted unless otherwise specified in the MOAPI.

3. General soils investigations and report requirements are outlined in Section 400. This Section defines requirements for soil testing and backfill requirements for all cut and fill areas within the right-of-way or public easements. The final pavement design report shall include follow-up testing for subgrade soil expansion, subsurface water, and R-value, in accordance with the specifications in this chapter

506.02 Existing Streets

For existing streets the Town Engineer may require deflection tests or other testing of the existing pavement and base structure to determine if any overlay is feasible, or if reconstruction is necessary.

506.03 A.A.S.H.T.O. Design

The design criteria and procedures presented follow American Institute of State Highway and Transportation Officials (A.A.S.H.T.O.) 1993 Guide for the Design of Pavement Structures.

506.04 Pavement Type

1. Streets are to be constructed of either asphaltic concrete pavement (AC) or Portland cement concrete pavement (PCC). AC shall be plant mix hot bituminous pavement also known as (HBP). AC or PCC shall be placed on base course material, subbase material (where required), and compacted subgrade.

2. All roadways built in the Town of Frederick shall have a ñsuperpaveò binder for the top lift of asphalt.

506.05 Treated Subgrade

The use of treated subgrade, treated base, and/or full depth asphalt pavement may be acceptable when designed and submitted by the designer, and approved by the Town Engineer in accordance with these standards.

506.06 Roundabouts

The pavement thickness design for the roundabouts shall be based on the sum of the 20 year design volumes from all legs. A separate design analysis is required. No default thicknesses are available. Refer to note 10 in Section 500.01.

506.07 Pavement Design Submittal and Review

1. Two copies of the Pavement Design Report must be submitted to the Town Engineer

2. All Pavement Design Reports shall include in the title the subdivision name and filing number. Also, include the Lot and Block numbers if the report does not apply to the entire filing. If the report does not relate to a specific subdivision, the name of the proposed development shall be listed.

3. When submitting a Pavement Design Report, the submitter shall provide the following information to the Town Engineer: name of the consultant, address (including zip code), telephone number, and fax number of the consultant; name of contact person, address (including zip code, telephone number, and fax number of the contact person.

4. All Pavement Design Reports shall include a Vicinity Map.

5. Town approval for Pavement Design Reports are valid for two years. An approved pavement design is REQUIRED before paving construction is allowed. If an approved Pavement Design Report is needed after two years from the original approval date, the consultant must revise the report to comply with the current Town of Frederick criteria or submit a letter referencing the original report stating that the

recommendations in the original report remain valid and continue to comply with the current Town of Frederick criteria.

507 GEOTECHNICAL REPORT

Rigid and Flexible pavement design shall be based on a geotechnical report stamped, signed, and dated by a Colorado registered Professional Engineer competent in the field of Geotechnical Engineering.

507.01 Soil Borings

1. Soil borings shall be advanced in the proposed or existing road. The subgrade shall be within 6 inches of its final elevation prior to any soil investigations intended to be used for final pavement design.

2. A minimum of one boring shall be obtained for any roadway segment. The distance between borings shall not exceed 250 feet along local and collector streets and fire lanes. One boring shall be made for every 15,000 square feet of public parking areas. The Town Engineer may require more frequent testing.

3. Borings shall be advanced to a minimum depth of 5 feet below the proposed subgrade elevation with every 4th boring a minimum of 9 feet below the proposed subgrade elevation.

4. Borings shall extend deeper if bedrock or high groundwater are design concerns.

5. Soil samples shall be taken based on the proposed subgrade elevations.

6. All borings shall be sampled using a ñCalifornia Barrelò style thin-walled type of sampler AASHTO T206 for fine grained soils and coarse grained soils. A split-spoon sampler may be used when recovery is not possible with the ñCalifornia Barrelò style sampler.

7. A scaled drawing with the boring locations plotted within 5ôhorizontally is required.

507.02 Minimum Information Required

1. Ground water elevations, if encountered

2. Drill logs with subgrade elevations

3. Gradation curves, AASHTO T27 (each sample of granular soils)

4. Atterberg Limits, AASHTO T89 and T90 (each soil type in each boring)

5. Soil classification, AASHTO M145 and ASTM D2487

6. Percent passing the No. 200 Sieve, AASHTO T11 (each soil type in each boring)

7. Natural moisture/density, AASHTO T265 (each CAL drive sample)

8. Moisture-density curves

9. Sulfate tests, AASHTO T290 (1 test per 500ôof fine grained soils)

10. Swell/consolidation tests, ASTM D4546 at 200 psf (except non-cohesive soils, one test every third boring, each road segment, or fraction thereof)

11. Effective resilient modulus of roadbed soils, Mr, for design of flexible pavements and effective modulus of subgrade reaction, K, for design of rigid pavements

12. Boring logs shall include boring number, standard penetration test results, free water, and any abnormal conditions

13. A map showing location or limits of different soil types

In addition, the Geotechnical Engineer shall investigate and recommend solutions to problems of:

1. Swell potential

2. Frost heave in silty soils

3. Potential ground water problems

4. Sulfates

5. Any other matter that may adversely affect the design and life of the pavement

508 SUBGRADE CHARACTERISTICS

508.01 Swell Potential

1. All soil groups, excluding A-1 through A-4, shall be tested to determine swell or settlement potential. Tests shall be run on the ñCalifornia Barrelò samples in accordance with ASTM D4546 at a surcharge of 200 psf. Test results shall be included in the pavement design report. Test results which are suspected of being too high or too low for the soil type shall not be considered in the design of the pavement, but shall be reported. Any deletion of data shall be justified in the report. The swell/settlement potential for a given soil shall be the calculated average of each of the classification groups.

2. As a minimum the report shall stipulate the following: the required depth of moisture treatment and chemical stabilization (if required) of the subgrade shall be determined by the highest average percentage of swell as recorded as a whole number as indicated in the table below:

Table 500-10 - Subgrade Treatment		
Swell Potential*	**Min. Depth of Moisture Treatment**	**Min. Depth of Chemical Stabilization**
< 3%	Moisture treat to a depth of 1ô	--
Ó3%, < 5%	Moisture treat to a depth of 2.5ôor	--
	Moisture treat to a depth of 1.5ô	Chemical treat to a depth of 1ô
Ó5%	Moisture treat to a depth 1.5ô	Chemical treat to a depth of 1ô

Notes:

1. Indicates average percentage of swell as recorded to the nearest whole number

2. Moisture treatment shall achieve a moisture content and compaction as specified in Section 400

3. Soils with >5% swell shall also require swell mitigation per Section 608, STABILIZED SUBGRADE, in addition to moisture treatment.

4. The above depths for Moisture Treatment and Chemical Stabilization are minimums only. If greater depths are recommended in the approved Pavement Design Report they shall be used.

508.02 Hveem Stabilometer

1. The poorest soil (based on AASHTO Classification) found in each street segment shall be used to determine the subgrade support value using Hveem Stabilometer (R-value) testing. Only one R-value test needs to be run for each soil type that will be used for design at the development. Hveem stabilometer tests shall be conducted in accordance with AASHTO T190. The design R-value shall be at 300 psi exudation pressure. The reported data shall include the following:
   a. Test procedure reference
   b. Dry density and moisture content for each sample
   c. Expansion pressure for each sample
   d. Exudation pressure, Corrected R-value curve showing the 300 psi design R-value

509 TRAFFIC – EQUIVALENT SINGLE AXLE LOADS (ESAL)

509.01 ESALs

1. ESAL is defined as total number of equivalent 18,000 lb. single axle load applications for the design lane during a 20-year design period. Calculated ESALs must be equal to or greater than the minimum ESALs listed in Table 500-11 below. The Town Engineer may increase the minimum ESAL at any location, if in his opinion traffic conditions warrant.

Table 500-11 - Minimum ESAL ($x10^6$)				
Road Classification	**Single-Family Residential**	**Multi-Family Residential**	**Commercial and Business**	**Industrial**
Arterials	2.2	2.2	3	4
4-Lane Collector	1.5	1.5	2.2	2.2
2-Lane Collector	0.2	0.2	0.4	1.1
Low Density Rural	0.07	--	--	--
Local Street	0.06	0.07	0.2	0.7
Fire Lane	--	0.07	0.2	0.2
Parking, Cars Only	0.04	0.04	0.04	0.04
Parking, All Other	0.04	0.04	0.07	0.07

Notes: An axle-load analysis must be approved by the Town Engineer if less than the minimum indicated ESALs are to be used.

2. Parking Areas
Traffic loads from Table 500-11 may be assumed.

3. Residential
If a traffic study for a residential roadway is not available, traffic loads can be determined using the following equation:
$ESAL_{R20} = 62,000 + 80\ R$
Where R = number of residential density units serviced by the street.

4. Commercial
For roadways where an individual commercial site is 10 acres or more, traffic loading shall be determined by an approved traffic study only. For commercial roadways with sites less than 10 acres, traffic loading can be calculated as follows:

$ESAL_{C20} = 62,000 + 80\ R + 260,000\ C_A$
Where C_A = Commercial Acres serviced by the street

5. Industrial
For roadways where an individual industrial site is 10 acres or more, traffic loading shall be determined by an approved traffic study only. The Town may require a traffic study for any industrial roadway. For industrial roadways with sites less than 10 acres, traffic loading can be calculated as follows:

$ESAL_{I20} = 260,000\ C_A + 260,000\ I_A$
Where I_A = Industrial acres serviced by the street.

Pavement design traffic studies are a method of determining 20-year design ESALs. ESAL calculations in traffic studies shall be based on the AASHTO "Guide for Design of Pavement Structures", latest edition. The traffic study, when required, shall be submitted with the pavement design and subject to review and acceptance.

509.02 Zoning Classifications

1. Roadway zoning classifications are based on the projected land use of the areas served by the subject segment of roadway.

2. Residential roadways service areas with a minimum of 80% residential zoned property.

3. Commercial and Industrial classifications service areas with 20% or more of the land to be used as Commercial or Residential. If less than 80% of the area served is residential, the Classification will be either Commercial or Industrial. If any of the non-residential area is served is Industrial, the classification will be Industrial. If none of the residential area is Industrial, the classification will be Commercial. Any classification with a calculated Equivalent Single Axle Load (ESAL) of 1.5×10^6 or more will be considered Arterial.

510 MINIMUM PAVEMENT THICKNESS

If the calculated pavement sections indicate thinner sections than the Minimum Pavement Sections listed in Table 500-12 below, the Minimum Pavement Sections shall govern. The Town Engineer may increase the minimum pavement section at any location if, in his opinion, conditions warrant. All asphalt roadways will be paved with a minimum of two (2) lifts, regardless of minimal thickness.

Table 500-12 - Minimum Pavement Sections

ESAL ($\times 10^6$)	Full Depth Asphalt	PCC*	AC and Aggregate Base
> 1.8	7 ½	7 ½	6 ½ñAC + 8" Aggregate Base
0.5 ï 1.8	7	7	6ñAC + 7" Aggregate Base
0.2 ï 0.5	6	6	3 ½ñAC + 7òAggregate Base
Less than 0.2	5 ½	5	3òAC + 6òAggregate Base
Parking Areas	5 ½	5	3òAC + 6òAggregate Base

* Concrete streets are only allowed with specific written approval of the Town Engineer

511 PAVEMENT MATERIALS

Asphalt Cement Concrete (AC) shall be plant mix hot bituminous pavement (also known as HBP). Use of other than AC, PCC, or gravel base requires submittal of appropriate test data for approval by the Town Engineer.

512 PAVEMENT DESIGN PROCEDURE

1. All pavement designs (non-rigid and rigid) should be performed in accordance with the most current version of the AASHTO ñGuide for Design of Pavement Structuresò (AASHTO Guide).

2. Alternatives to the use of the above-mentioned AASHTO Guide may be presented for approval as follows: computer programs/printouts that present results in accordance with the equations and procedures outlined in the AASHTO guide will be

allowed for review. The printout must reiterate all design parameters. The report must justify to the satisfaction of the Town Engineer any deviation from the design parameters specified herein.

512.01 Pavement Design Factors (Based on AASHTO)

1. Reliability (R)
   a. 95% for arterials, all fire lanes, all commercial and industrial roadways
   b. 90% for local and collector roadways and parking lots other than commercial and industrial. Except local roadways and private drives where the area to be served by the roadway is 90% or more developed, R=85% may be used.

2. Overall Standard Deviation (So)
   a. 0.45 for flexible pavements
   b. 0.35 for rigid pavements

3. Design Serviceability Loss

Table 500-13 - Design Serviceability Loss		
Flexible	**Rigid**	
2.2	2.5	Local and collector roadways, other than commercial and industrial, private drives, and parking lots.
1.7	2	Arterials, fire lanes, all commercial and industrial roadways

4. Concrete Elastic Modulus (E_c)
   $3.6 * 10^6$ psi

5. Mean Concrete Modulus of Rupture (S'_c)
   600 psi

6. Load Transfer Coefficient (J)
   If monolithic or tied curb and gutter are placed on both sides of the pavement use 3.6, otherwise use 4.2

7. Drainage Coefficient (C_d)
   1.0

8. Loss of Support (LS)
   2.5 for use in Figure 3.6 of the AASHTO Guide to correct the Effective Modulus of Subgrade Reaction, K, for potential loss of support.

513 PAVEMENT DESIGN REPORT REQUIREMENTS

1. Design nomographs and/or computer program printouts

2. Map showing the location of each different pavement section and soil type

3. Design calculations for each pavement section

4. Original stamp and signature of the Geotechnical Engineer

5. Swell potential discussion

6. Discussion of any unusual design or construction problems or requirements

7. All information indicated in Section 507.

514 GENERAL - CONSTRUCTION

1. "Streets" as used in this specification shall include the pavement section, right-of-way, sidewalks, driveways, bikeways, alleys and alley approaches.

2. All materials and construction shall be done in conformance with the Town of Frederick Standard Specifications and the approved plans. Where these Standards do not address situations, materials, or construction requirements the Town of Frederick shall utilize the requirements of the Colorado Department of Transportation, "Standard Specifications for Road and Bridge Construction" and any applicable HBP mix design and material requirements of Item 9 of the most recent version of Metropolitan Governments Pavement Engineers Council (MGPEC) Pavement Design Standards. Requirements contained in the "Standard Specifications for Road and Bridge Construction" are intended to supplement these Town standards.
   a. The term "State Specifications" and "CDOT" in these standards refers to Colorado Department of Transportation, Division of Highways, State of Colorado "Standard Specifications for Road and Bridge Construction". Sections 100 through 109 and measurement and payment provisions of the "State Specifications" shall not apply. Reference in these specifications to the "Division" shall be understood to refer to the Town of Frederick and its authorized personnel.
   b. The Town of Frederick standards and specifications shall take precedence over conflicting provisions in the CDOT standard specifications and other referenced standards.

3. Where new construction ties into existing improvements, such as edges of pavement, sidewalks, curbs, etc., the Contractor shall line out and cut or saw the existing improvements to a true line and to an approved depth with a vertical face at the line of removal. Where the existing improvements are damaged, the Contractor shall remove the damaged improvements and shall tie-in to improvements which are in good condition as determined by the Inspector.

514.01 Sequence of Construction

1. All installation and proper compaction of buried utilities shall be completed prior to the construction of the subgrade, base course, pavement, curb, gutter, crosspans, sidewalks, bikeways and driveways. However, with approval of the Engineer, in situations where a water service line has been added, modified, or inadvertently

missed, water service lines may be installed after the curb, gutter and sidewalks have been placed at least 7 days, providing no damage is done to the street improvements. The Contractor shall adjust valve boxes and manholes to final grade after installation of the curb and gutter as described below. Electrical services Dry utility road crossing sleeves shall be installed after the water services but prior to the installation of curb radii. Except where previous arrangements for use of conduit have been made and approved by the Town Engineer.

2. Prior to commencing paving operations, a pre-paving meeting shall be held.

3. After lower lift paving is installed, no cuts shall be made without the approval of the Town Engineer or Town Representative. If utility installation is required after installation of curb, gutter, sidewalk or pavement; boring, jacking, or other alternative means of construction will be utilized.

4. If a pavement cut is permitted after installation of the top lift of pavement, the Town may require heater scarifying (infra-red) of patch joints, overlaying of the street, or other techniques approved by the Town to avoid any reduction in useful life of the pavement.

514.02 Fixture Adjustment

1. The Contractor shall adjust all manholes, valve boxes and other fixtures encountered within the area to be paved to conform to the finished surface of the pavement to be built as per the street plans and details and in accordance with all requirements outlined in these specifications. Clean the outside of the fixtures of loose, foreign material for the depth of the pavement prior to the paving. The Contractor shall adjust manhole castings, valve boxes and other fixtures outside the paved areas, but within the street right-of-way, to conform with the finished cross section after construction. Inspect valve boxes by placing a valve key on the operating nut to assure a proper alignment. All adjustments shall be to proper alignment and grade to the satisfaction of the Town Engineer or Town Representative.

2. Manholes, valve boxes and other fixtures shall be adjusted to the interim street grade after the installation of the lower lift of pavement to produce a safe and rideable surface around the fixture. Prior to placing the final lift of asphalt, manholes, valve boxes, and other fixtures shall be adjusted to the final street grade.

514.03 Protection and Cleaning

1. The Contractor shall take proper precautions for the protection of all existing improvements which are to remain in place and all other identifiable installations that may be encountered during construction which are to remain and not be replaced.

2. The Town Engineer shall be the sole judge as to whether items may be reset and reused. If, in the opinion of the Town Engineer, items that were allowed to be reused and reset are damaged during construction the items shall be replaced by the Contractor.

3. The Contractor is responsible for site cleaning during the entire construction period. After paving operations have been completed, the Contractor shall clean and remove all leftover and waste materials. All curbs shall be properly backfilled and the adjacent ground left in a neat and uniform condition, acceptable to the Town Engineer.

514.04 Clearing and Grubbing

1. This work shall consist of clearing, grubbing, removing and disposing of vegetation and debris within the limits of the right-of-way, easement areas, and such other areas as may be indicated on the drawings or required by the work, except such vegetation and objects designated to remain.

2. The Contractor shall remove and dispose of protruding obstructions, stumps, roots and matted roots over 4 inches in diameter to two feet below the finished grade. Backfill all holes resulting from the removal of obstructions, stumps, and roots and compact the backfill to 95% of Standard Proctor, ASTM D698. Undisturbed stumps, roots, and nonperishable solid objects located two feet or more below the subgrade may remain in place.

3. The Contractor shall clear and strip all surface vegetation, sod, and topsoil from subgrades for permanent construction, fills and embankments. Undisturbed stumps, roots, and nonperishable solid objects located two feet or more below the subgrade may remain in place.

4. The Contractor shall trim or remove and dispose of branches of trees extending over the roadway to a clear height of 15 feet above the roadway surface. All removal and trimming shall be done in accordance with good tree surgery practices and with approval of the Town Engineer.

514.05 Removal of Structures and Obstructions

1. This work shall consist of the removal, wholly or in part, and the satisfactory disposal of buildings, foundations, fences, signs, structures, old pavements, abandoned pipelines, and other obstructions which are not designated on the drawings to remain.

2. Where culverts or sewers are to be abandoned in place under local streets, the culvert and sewer ends are to be sufficiently filled or crushed to prevent the future settlement of embankments and backfills. Fill the ends of concrete, plastic or masonry culverts with concrete and crush the ends of metal culverts. The removal and plugging of culverts shall include the removal of head walls and other appurtenances that are necessary to accommodate the work.

3. All culverts or sewers to be abandoned under collector and arterial streets shall be flow-filled where they are located longitudinally within the public right-of-way. Unless otherwise approved by the Town Engineer, the culverts or sewers that cross the public right-of-way under collector and arterial streets shall be removed.

4. The Contractor shall not remove sidewalks, streets, driveways, culverts, or other drainage structures in use by traffic or pedestrians until satisfactory arrangements acceptable to the Town have been made to accommodate traffic and drainage.

5. Culverts designated to remain shall be cleaned at the end of construction by removing all sediment and debris from within the culvert and appurtenant structures.

6. All structures designated to partially remain within the right-of-way shall be removed to a depth of two feet (2') below the proposed subgrade.

515 EXCAVATION AND EMBANKMENT

515.01 General

1. This section covers excavation, hauling, disposal, placement, subgrade preparation, shaping, backfill, compaction, and embankments.

2. For these specifications "Roadbed" is defined as the graded portion of a roadway prepared as a foundation for the pavement structure, gutters, and sidewalks.

3. The Contractor shall complete all necessary clearing and grubbing and removal of obstructions prior to beginning grading operations.

4. The Contractor shall not begin site grading until the work has been properly staked. The Contractor shall not excavate beyond the dimensions and elevations established.

5. Completed or partially completed areas of work that are disturbed by subsequent construction operations or by adverse weather shall be scarified, reshaped, and recompacted to the required density.

515.02 Materials

1. Generally, soil materials for roadway construction shall be as recommended in the approved soils report. The following soils materials are the minimum requirements for the materials to be used in the construction of roadways.

2. Embankment and fill material shall consist of soil, granular sand, gravel, cobble and boulder material, free from frozen material, organic material, trash, glass, broken concrete, other corrosive or deleterious material. The Contractor shall import approved material as necessary. Prior to placement of any imported material, the Contractor shall submit test results to the Town for review and approval indicating compliance with the requirements of the soils report and design standards.

   Approval of embankment and fill material is contingent on the material having a resistance value when tested by the Hveem Stabilometer, or equivalent resilient modulus value, of at least that specified in the approved plans and a maximum dry density of not less than 90 pounds per cubic foot. The material must be stable and have a liquid limit less than 40 and a plastic index less than 15 when tested in accordance with AASHTO T-89 and T-90, respectively. Size restrictions are as follow:

   a. No material shall have a dimension larger than six (6) inches. In the top

eighteen inches of fill, no material shall have a dimension larger than four (4) inches.

b. These size restrictions are contingent upon the material being evenly distributed in finer material such that uniform soil consolidation is achieved. If uniform soil consolidation is not being achieved the Engineer may reduce the size of materials allowed or change the embankment and fill material requirements.

3. Where unstable subgrade is encountered, the Contractor shall take steps necessary to stabilize the material by techniques such as over excavation and backfill with imported material, use of geotextile fabrics, or other combinations. The contractor shall notify the Engineer of the proposed solution to stabilize the subgrade. If required by the Town, the Developer's Design Engineer will make recommendations on stabilization techniques and materials.

515.03 Subgrade

1. The Contractor shall scarify the subgrade to the depth specified in the approved soils report and compact to the density specified within the approved soils report. In no case shall the depth be less than twelve (12) inches, or the compaction less that specified in these specifications.

2. The Contractor shall not place any embankment, fill, base course, pavement or other permanent improvements on frozen or muddy subgrade. Compact and consolidate subgrades such that they are free from mud and sufficiently stable to remain firm, dense and intact.

3. Wherever material is encountered that is wet or otherwise unstable and is incapable of supporting structures or the roadbed the material shall be over excavated to a depth suitable for construction of a stable subgrade. The Contractor shall backfill over excavated areas with a stabilization material approved by the Town Engineer. An approved filter fabric shall be used where required around the Stabilization Material and on the subgrade to stabilize the subgrade and prevent fines from migrating into the Stabilization Material.

4. Level and roll the subgrade so the materials will be uniformly compacted and bond well with the first layer of the base course, backfill, fill or embankment.

5. Shape the surface of the subgrade under areas of base course, and pavement surfaces so that they are not more than 1/4" above or 1/2" below the required subgrade elevation. Shape the surface of the subgrade under structures such that they are not more than zero inches above or 1 1/4 inches below the required subgrade elevation. Fill areas of the subgrade that are low with the material to be placed upon the subgrade. Shape the subgrade to prevent the ponding of water from drainage and rain.

6. Where pipe will pass through backfill, embankment or fill; the Contractor shall place and compact the backfill, embankment or fill to an elevation at least one foot above the top of the proposed pipe prior to beginning trenching.

7. Remove exposed cobbles, stones or boulders greater than four (4) inches in size that create an irregular surface at the subgrade under base course material. Backfill the resulting voids with base course material and compact to the specified density.

515.04 Excavation

1. The Contractor shall remove and dispose of excess excavated materials and materials that are not suitable for use within the public right-of-way.

2. Foundations and the pavement structure shall be founded on original, undisturbed soil or on structural backfill extended to the undisturbed soil. Unless otherwise approved by the Engineer and stipulated in the approved soils report, foundations and the pavement structure shall not be founded on existing fill if encountered at the project site. If existing fill is encountered at the subgrade, the Contractor shall excavate to original undisturbed soil and bring the grade to the required elevation with approved material. Existing fill material if encountered at the site shall be removed. Existing fill may be stockpiled for reuse in backfills and embankments if it meets the requirements of the specifications. The Contractor shall remove unsuitable soil material as directed by the Engineer. The disposal of unsuitable soil material is the responsibility of the Contractor.

3. Excavate rock that is encountered at the site to a minimum depth of 6 inches below subgrade within the limits of the roadbed.

4. The Contractor shall blend the intersection of cut slopes with the slopes of adjacent natural ground surfaces in a uniform manner. The tops of cut slopes shall be flattened and rounded in accordance with the approved plans. Slopes shall be graded as shown on the Approved Plans, shall not exceed a 4:1 slope unless otherwise approved by the Engineer, and shall be graded to drain.

515.05 Backfill, Fill and Embankment

1. The Contractor shall import approved material if compaction cannot be obtained with job excavated material, or if job excavated material does not meet the criteria in Table 200-01, or the requirements of the geotechnical report. The Contractor shall provide the proper documentation showing that the existing and imported materials meet the appropriate criteria.

2. Place the backfill, fills and embankments on suitably prepared subgrades. Distribute material so as to preclude the formation of lenses of material differing from the surrounding materials. Lifts shall have uniform thickness prior to compaction and shall not exceed 8 inches in uncompacted thickness. Spread and level material that is deposited in piles or windrows prior to compaction. Continuously mix, level, and manipulate the material as compaction progresses to assure uniform moisture and density.

3. The Contractor shall insure that the methods of compaction shall not overturn or place excessive pressure against structures such as retaining walls, abutments, wing

walls, or culvert head walls where backfill, fills or embankment is placed on only one side of structures. When backfill, fill or embankment is placed on all sides of a concrete structure, the embankment shall be brought up equally on all sides of the structure. The fill adjacent to the abutment of a bridge shall not be placed higher than the bottom of the backwall until the superstructure is in place.

4. Where embankments encroach on stream channels, ponds or lakes, the largest available rock from the excavation shall be placed along the toes of slopes to protect the embankments against erosion from water action. The Engineer may require the use of riprap along channels, ponds and lakes. All environmental and grading permits shall be obtained from the US Army Corps of Engineers, Colorado Department of Public Health and Environment and Town of Frederick prior to construction adjacent to stream channels, ponds or lakes.

5. Rock embankment, if allowed, shall not be constructed above an elevation two feet below the finished subgrade. The balance of the embankment shall be placed in layers not to exceed eight inches loose thickness and compacted as specified for embankments. When rock fill is placed over any structure, the structure shall be covered with a minimum of two feet of compacted earth or other approved material before the rock is placed.

6. Cross hauling or other action as appropriate will be required by the Town Engineer when necessary to insure that the best available material is placed in critical areas of embankments.

7. The Contractor shall use equipment suited to the soil being compacted. Compaction by use of water ponding or jetting or use of a hydro-hammer is strictly forbidden.

515.06 Finish Grading

1. After the pavement, permanent surface improvements, structures, backfills and fills have been completed the Contractor shall grade non-paved areas to slopes, contours or elevations indicated on the Drawings. Finish grading shall ensure proper positive flow and drainage. Conduct final rolling operations to produce a stable, uniform and smooth cross-section. Provide effective drainage with slopes of at least two (2) percent unless otherwise indicated.

2. Where topsoil is to be placed in the non-paved areas the Contractor shall provide allowance for topsoil placement. Finish grade areas to receive topsoil to within not more than 0.1 feet above or below the required subgrade elevations. Compact areas to receive topsoil as specified and grade such that they are free from irregular surface changes.

515.07 Compaction and Testing

1. The Contractor, at their expense, shall test the subgrades, fills, backfills and embankments for compliance with the requirements for thickness and compaction density. Provide, as a minimum, one (1) density test for each 150 linear feet of subgrade, one (1) density test for each 100 lineal feet of curbwalk, and one (1)

density test for each 500 cubic yards of embankment, fill or backfill. The Town Engineer may designate the locations for testing and may require more tests when in the Townôs opinion they are required. Remove and replace unacceptable materials and repair unacceptable areas of thickness or compaction as required by the Engineer. Compaction tests do not relieve Contractor of the requirement for a firm, stable surface.

2. Field compaction densities shall be as indicated in the soil report but not less than the following minimum Standard Proctor densities, reference ASTM D698.
   a. All compaction within the public right-of-way shall be equal to 95% compaction at plus or minus 2% optimum moisture content.
   b. Do not compact topsoil.

3. Proof roll the subgrade and base course prior to the placement of the subsequent course after the specified compaction densities have been obtained. Proof rolling shall be done with an approved vehicle having an average minimum axle load of 18,000 pounds per axle. Use of graders or front-end loaders is not acceptable. Areas that show movement and unstable areas shall be corrected. Proof rolling shall be done within 24 hours of the compaction density testing and within 24 hours of placement of any asphalt or concrete surface. Any moisture (i.e.-snow or rain) that enters the soil after the density tests and proof roll have passed but has not been paved yet must be retested for density and re-proof rolled before pavement may be constructed.

515.08 Aggregate Base Course

1. The Contractor shall mix the aggregate by methods that insure a thorough and homogenous mixture.

2. The subgrade and base course shall be free from standing water during construction. Remove any water encountered during construction to the extent necessary to provide a firm and stable subgrade and base course. Divert surface runoff or use other means necessary to accomplish the above. Do not deposit, tamp, roll or otherwise mechanically compact the aggregate base course in water. Do not construct aggregate base course with frozen material or on frozen subgrade.

3. Aggregate base course shall be crushed stone or crushed gravel conforming to Section 703.03 of "State Specifications" with an minimum "R" value of 70. The soils report shall identify areas that in the soils engineer's opinion need to be treated with mineral filler or hydrated lime. Commercial mineral filler if required shall conform to Section 703.01 of the "State Specifications". Hydrated lime shall conform to Section 712.03 of the "State Specifications".

4. If the required compacted depth of the aggregate base course exceeds six (6) inches, it shall be constructed in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer of aggregate base course shall not exceed six (6) inches. The surface of each layer shall be maintained during the compaction operations so that a uniform texture is produced and the aggregates are firmly keyed. Water shall be uniformly applied during

compaction in the quantity necessary for proper consolidation of the material, or the material shall be harrowed, disked, bladed, or otherwise worked to insure a uniform moisture content. Immediately prior to paving, proof roll the aggregate base course to verify the base course stability. Areas that are not stable must be corrected and proof rolled again until all areas pass.

5. Herbicides, conforming to the requirements of Section 217 of the "State Specifications", shall be applied to the aggregate base course and/or subgrade no more than 1 day prior to paving. The rate of application shall be as recommended by the herbicide manufacturer. Herbicides shall not be used where they may contaminate water used for irrigation or drinking purposes.

6. As a minimum, the Contractor shall provide one field compaction test for each lift of aggregate base course for every 150 linear feet of base course placed. The Engineer may designate the locations for testing. The aggregate base course shall be compacted to 95% minimum density, Modified Proctor, ASTM D1557 or AASHTO T180. All compacted aggregate base course shall be within 2% (+) of the optimum moisture content of the soil as determined by ASTM D1557. The Engineer may require more tests when in their opinion they are required due to visibly unstable areas. Remove and replace unacceptable materials and repair unacceptable areas of thickness or compaction as required by the Engineer. Compaction tests do not relieve Contractor of the requirement for a firm, stable surface.

7. The in-place compacted thickness of aggregate base course shall be no more than 1/4 inches less than the thickness shown on the approved drawings.

8. Test the finished surface of the compacted aggregate base course for smoothness using ten foot straightedge applied parallel with, and at right angles to centerline of the paved area. Any deviation in excess of ¼ò shall be corrected to the satisfaction of the Engineer.

516 PLANT MIXED BITUMINOUS PAVEMENT

516.01 General

1. Prior to beginning paving each calendar year, the Contractor shall submit to the Town Engineer for review and approval a mix design for each mix. The Town Engineer may also require mix designs from the Contractor during the year because of changes in the physical properties of the aggregate, source of the aggregate, or other changes in the mix.

2. The job mix formula for each mixture shall establish a single percentage of aggregate passing each required sieve size, a single percentage of bituminous material to be added to the aggregate and a single temperature for the mixture at the discharge point of the plant. The job mix formula shall also identify all additives, optimum asphalt content and the final gradation shown on 0.45 power graph. Mix designs shall also provide the results of a moisture susceptibility test (Lottman) performed at optimum oil content in accordance with CP-L 5109, method B. Where reclaimed asphalt is used in the job mix, the design report shall address the use of reclaimed

asphalt and the percent of asphalt in the reclaimed asphalt. Submit the following with the job mix formula.

a. The proposed job mix gradation for each mixture which shall be wholly within the Gradation Range Table before the production (job mix) tolerances are applied.
b. The aggregate source, gradation, additive blending, aggregate physical properties, and percentage of each element used in the production of the final mix.
c. The name of the refinery supplying the asphalt cement, source and grade of performance graded binder, source of lime, and the source and type of anti-strip additive.

3. After the job mix formula is established, all mixtures furnished for the project shall conform to the approved job mix formula within the range of production tolerances.

4. Mix design (production) verification shall occur prior to the start of the project. Mix design (production) verification shall be performed by LABCAT Level C accredited technicians to verify the volumetric properties of the mix. If the mix has been produced for another project within the last 90 days, data from that project can be submitted for verification. The mix verification test reports shall be submitted to the Town prior to mix placement.

5. Volumetric properties shall be within the following tolerances. The tolerances in the following table are for mix design verification only (from plant produced material from the specified mix design). See Job Mix (Production) Formula Tolerances table for production tolerances.

Table 500-14 - Mix Design (Production) Verificaton Tolerances	
Air Voids	±-1.2%
VMA	± -1.2%
Asphalt Cement Content	± -0.3%
Stability	Applicable Minimum

6. Change in Source or Grade

Should a change in the source of Lime occur, or more than one temperature grade change on either the high or low end of Asphalt Binder (AC) occur, a one point verification test (at optimum asphalt content) of the mix must be performed to verify that the applicable criteria is still met. If this testing shows noncompliance, a new Design Job Mix shall be established before the new AC or Lime source is used. Any change in aggregate type or source will require a new mix design. The one point verification test may be performed on lab mixed samples or on Plant mixed samples.

Production test results shall comply with the following table:

Table 500-15 - Job Mix (Production) Formula Tolerances	
Passing No. ¾ò and Larger	6%
Passing No. 4 and No. 8	5%
Passing No. 30	4%
Passing No. 200	2%
Air Voids	1.20%
VMA	1.20%
Hveem Stability	See Footnote #3
Asphalt Content	0.30%
Asphalt Content, Mixes with >10% RAP	0.40%

Notes:

1. There is 1.0 percent tolerance for the maximum sieve size.

2. Mixes with -No.200 sieve material produced over 7.0 percent is allowed only when Air Voids are kept within 1.2 percent of the Air Voids at mix design optimum and VMA still meets requirements.

3. Hveem Stability must meet the minimum value specified in Superpave Mixture Properties table.

4. Hot bituminous pavement Gradation SG may contain up to 25 percent reclaimed asphalt pavement and Gradation SX shall not contain more than 15 percent reclaimed asphalt pavement where approved by the Town Engineer. Reclaimed asphalt pavement where allowed shall meet the requirements of Section 703.04 Gradation SG of the "State Specifications" and must meet all the requirements for hot bituminous pavement.

516.02 Materials

1. Hot plant mixed bituminous pavement aggregate shall conform to the material requirements of Item 9 of the most recent version of Metropolitan Governments Pavement Engineers Council (MGPEC) Pavement Design Standards. Use Grade SG aggregate mix for the bottom lift of full depth asphalt sections, aggregate mix S for the bottom lift of composite sections, and use Grade SX for the surface course and overlays.

2. Joint and crack sealant shall conform to Section 408.01 through 408.03 of the "State Specifications".

516.03 Construction Requirements

1. ñState Specificationsò refers to the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction.

2. Before starting the paving, the Contractor shall insure that utility lines, piping, general grading and heavy trucking are complete so such operations will not damage paving work. No less than one day prior to paving, the Engineer MUST receive all test results stating that the subgrade and/or aggregate base is approved.

3. Prior to placing the pavement, the Contractor shall adjust manhole frames, valve boxes and other fixtures.

4. Weather limitation requirements for construction of hot bituminous pavement shall be in accordance with the following table:

Table 500-16 - Minimum Air and Surface Temperature Limitations for Mix Placement

Compacted Layer Thickness	Top Layer of Pavement*		Lower Layers	
	PG 58-28 PG 64-22	PG 76-28	PG 58-28 PG 64-22	PG 76-28
< 2 inches	60 F	75 F	N/A	N/A
2 inches to < 3 inches	50 F	65 F	40 F	50 F
> 3 inches	50 F	50 F	40 F	40 F

* Air temperature is taken in the shade. Surface temperature is taken on the subgrade or base.

* Do not place the mixture at a temperature lower than 245 degrees Fahrenheit or 290 degrees Fahrenheit for mixes containing polymer modified asphalt.

5. Requirements for construction of hot bituminous pavement shall be in accordance with Section 401.08 through 401.19 of the "State Specifications", except as modified herein.

6. Apply a tack coat, prior to bituminous paving, to the contact edges of previously constructed bituminous layers, Portland cement concrete surfaces, and metal surfaces abutting or projecting into the bituminous pavement. Tack coat the surface of the previously constructed bituminous layer when more than eight hours passes between paving of lifts. Distribute the tack coat at rate of 0.10 gallons per square yard or as otherwise directed. Allow the tack coat and prime coat to dry until tacky to touch prior to bituminous paving. Paving equipment shall be in accordance with Section 407.05 and surface preparation shall be in accordance with Section 407.06 of the "State Specifications".

7. Unless approved otherwise by the Town Engineer, bituminous pavement shall be placed in ribbons 12 foot wide. After the first ribbon is placed and rolled, place succeeding ribbons and extend screen to overlap previous strips by not less than six inches. The Contractor shall arrange paving operations so there will be no exposed longitudinal joints between adjacent travel lanes at the end of a dayôs run for all local

roadways. Longitudinal joints for collector and arterial roadways shall be constructed in accordance with all applicable CDOT Specifications.

8. After final rolling, Contractor shall not allow vehicular traffic on pavement until pavement has cooled sufficiently to avoid damage to the surface.

9. In areas where the Town Engineer allows patching the Contractor shall cut out the old bituminous pavement and clean, fill and compact the area with fresh, hot plant mix bituminous pavement. Remove the deficient areas the full depth of bituminous pavement to one foot outside the entire area of the failure or as marked in the field by the Town Engineer. Cut the sides of the patched area vertically, perpendicular and parallel to the direction of traffic flow. All subgrade material shall be compacted to 95% of standard proctor. All aggregate base course shall be compacted to 95% minimum density, Modified Proctor, ASTM D1557 or AASHTO T180. Remove and dispose of the spoiled material and clean the area thoroughly. Apply tack coat to exposed surfaces and base course before placing new pavement. Replace the bituminous pavement in the patched area with full depth hot plant mixed bituminous pavement in lifts not exceeding 3 inches in compacted thickness. Compact the lifts to between 92% and 96% of Maximum Theoretical (Rice) density.

516.04 Test Requirements/Tolerances

1. Density, Gradation and Extraction - Test and monitor the bituminous pavement compaction density with a nuclear gauge on a continuous basis during the paving operation. The Town Engineer may require that core samples of the compacted bituminous pavement be taken by the Contractor at random locations on the project for testing of compaction and compliance with the design mix. Where the core samples have been taken, new material shall be placed and compacted into the holes by the Contractor to conform with the surrounding areas.

2. Compaction density shall be to between 92% and 96% of Maximum Theoretical (Rice) density. One test per 150 L.F. of pavement shall be required per day with a minimum of six tests per project. Tests shall also be taken by the Contractor to indicate the aggregate gradation, percent of air voids, and percent asphalt to verify compliance to approved pavement design. The Contractor shall perform, as a minimum, Rice test and gradation and extraction test per day of paving operation, unless the paving for the day is less than 100 tons. The test results shall be signed by a Professional Engineer employed by an independent testing company paid for by the Contractor. The in-place pavement shall be tested for compliance with the requirements for surface smoothness. The Town Engineer may order additional testing at the Contractor's expense if the Town feels it is necessary to determine that the pavement is acceptable or to determine the extent of unacceptable pavement. Repair or remove and replace unacceptable pavement as required by the Town Engineer.

Table 500-17 - Schedule for Minimum HBP Materials Sampling and Testing		
Test	**Standard**	**Minimum Frequency**
Density	ASTM D2950, CP-44, CP-81, CP-82	One Test for Each 150 Lineal Feet/Lane
Thickness (Core)		One Test for Each 1,000 Lineal Feet/Lane
Air Voids and VMA	CP-44 & CP-48	One for Each Day
Gradation	AASHTO T27	One for Each Day
Hveem Stability	CP-L 5106, T 245	One for Each Day
PG Binder ï AC Content	CP-L 5120 or AASHTO T164	One for Each Day
Moisture Susceptibility (Lottman)	CP-L 5109, Method B	One For Each 3rd Day
Maximum Theoretical Specific Density (Rice)	CP-51	One for Each Day

3. The Town may check pavement temperatures, segregation, rolling patterns and other construction means and methods, which affect the performance of the pavement system. The Contractor shall provide assistance in sampling and testing at all facilities and at the job site.

516.05 HBP Compaction

1. The temperature of the mixture immediately behind the screed shall be at least 245° Fahrenheit (290° Fahrenheit for polymer modified asphalt) and breakdown compaction shall be completed before the mixture temperature falls 20° Fahrenheit.

2. Rolling: Both steel wheel and pneumatic tire rollers are required. The number, weight, and type of rollers furnished shall be that which is sufficient to obtain the required density while the mixture is in a workable condition.

3. Compaction shall begin immediately after the mixture is placed and be continuous until the required density is obtained.

4. If the required density is not achieved and the surface temperature falls below 185° Fahrenheit, or there is obvious surface distress or breakage, no further compaction effort will be permitted unless approved by the Engineer. The criteria for mixtures containing polymer modified asphalt cements shall be 235° Fahrenheit.

5. Suspend pavement operations when density requirements are not met.

6. Remove all roller marks with the finish rolling. Use of vibratory rollers with the vibrator on will not be permitted during surface course final rolling and will not be permitted on any rolling on bridge decks covered with waterproofing membrane.

7. Compact all HBP paving to between 92 and 96 percent of Maximum Theoretical

(Rice) Density (CP 51: Maximum Specific Gravity of Bituminous Paving Mixtures) with the average of five random and consecutive density tests equaling at least 93 percent of T209.

8. Compaction of less than 92 percent of maximum theoretical (Rice) density will be cause for removal and replacement.

9. Use the most recent maximum theoretical (Rice) density in calculating Relative Compaction according to CP-44.

10. Core the pavements for field density tests in accordance with Colorado Procedure 44, Method B, or for field calibration of nuclear density equipment in accordance with the Appendix of Colorado Procedure 81 (ASTM D2950).

11. At a minimum, take cores for nuclear density equipment calibration at the beginning of placement of each pavement layer or change of mixture materials or gradation.

12. Untested areas during placement will also require cores to be taken to verify compaction.

13. Thickness - The in-place compacted thickness for hot plant mix bituminous pavement shall not vary from the required design thickness by more than 1/4 inches less than the required design thickness and shall have no limitation on the greater thickness.

14. Tolerances - The surface tolerance for pavement shall not be greater than 3/16 of an inch, as measured with a ten foot straight edge. If 10% or more of the final pavement surface fails to meet these tolerances, or requires repairs in the form of patching, the Developer shall be required to overlay the entire surface prior to final acceptance.

517 PORTLAND CEMENT CONCRETE PAVEMENT

517.01 Materials

1. Concrete pavement shall conform to the requirements for Class "P" concrete as specified in Section 601.02 and 601.03 of the "State Specifications". All concrete shall be ready mixed concrete. No concrete shall be field mixed. The proposed mix shall be tested in accordance with ACI code requirements. Two copies of the certified test reports shall be submitted to the Town Engineer, for acceptance, prior to ordering of concrete.

2. Proportioning of the concrete shall conform to Section 601.05 of the "State Specifications". The Contractor shall include Class F fly ash in concrete for paving. The quantity of Class F fly ash shall be equal to 20 percent of the weight of cement shown in Table 601-1 in the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction and shall be included in addition to the full weight of cement shown in the Table. The voluntary substitution of fly ash as permitted in Section 601.05 is not permitted.

3. Additives for concrete, other than those specified in the mix design, shall not be used without prior approval of the Town Engineer. When approved for use, chemical admixtures or additives shall comply with applicable ASTM or AASHTO standards. Calcium chloride or admixtures containing chloride shall not be allowed in reinforced concrete.

4. The batching of concrete shall conform to Section 601.06 of the "State Specifications".

5. The mixing of concrete shall conform to Section 601.07 of the "State Specifications".

6. Equipment used for concrete mixing, conveyance and placement shall conform to Section 412.07 of the "State Specifications".

517.02 Construction Requirements

1. Before starting the paving, the Contractor shall insure that utility lines, piping, general grading and heavy trucking are complete so such operations will not damage paving work.

2. Prior to placing the pavement, the Contractor shall adjust manhole frames, valve boxes and other fixtures.

3. Submit to the Engineer for approval a construction joint pattern showing types of each joint and joint spacing prior to paving operations. The pattern shall be based upon the Colorado Department of Transportation, M-Standard M-412-2, except that Expansion Joint Detail A shall be revised to a non-thickened section and shall include a smooth dowel sized 1/8 the concrete slab thickness at the mid-thickness of the slab, and 14 inches long placed at 12 inch centers with an expansion cap on one side of the joint.

4. Construction requirements for concrete pavement shall be in accordance with Section 412.08 through 412.21 of the "State Specifications", except as modified herein.

5. The Contractor shall submit to the Engineer the ready mix delivery tickets for each load upon request by the Engineer indicating the following:
   a. Supplier's name and date.
   b. Truck number.
   c. Project number and location.
   d. Concrete class designation.
   e. Cubic yards batched.
   f. Mix design identification.
   g. Type, brand, and amount of cement and fly ash.
   h. Brand and amount of all admixtures.
   i. Weights of fine and coarse aggregates.
   j. Moisture content of fine and coarse aggregates.
   k. Gallons of batch water.
   l. Time at which water was added.

m. Elapsed time between when water was added and concrete load was in place.
n. Amounts of initial and supplemental water added.
o. Name of individual authorizing supplemental water.
p. Numerical sequence of delivery by indicating cumulative yardage delivered on each ticket.
q. Provide the following titles with blank space to record discharge time, water-cement ratio, air content, slump, and revolutions.

6. Prior to concrete placement the Contractor shall remove all construction debris and extraneous matter from within the forms. Stays, bracing and blocks, serving temporarily to hold the forms in correct shape and alignment, shall be removed as the concrete placement progresses. All concrete shall be placed on a clean damp surface, free from standing water, and properly consolidated subgrade. Concrete shall not be placed with a free fall greater than 4' to prevent segregation of the concrete.

7. The time elapsing from the time water is added to the mix until the concrete is deposited in place at the site of the work shall not exceed the following time limits:
a. Air temperature 45 degrees F. to 80 degrees F. - 90 minutes maximum.
b. Air temperature over 80 degrees F. with a retarder added to the mix - 90 minutes maximum.
c. Air temperature over 80 degrees F. without a retarder added to the mix - 60 minutes maximum.

8 The opening of concrete pavement to vehicular traffic, including the Contractor's vehicles, will not be permitted until the compressive strength of the concrete test cylinders, tested in conformity with the latest ASTM Standard Method of Test for "Compressive Strength of Molded Concrete Cylinders," Designation C39 is at least 3,000 pounds per square inch. If permanent shoulders or curbs are not in place, a 6-foot wide temporary earth shoulder shall be placed against the outside pavement edges before traffic is allowed on the pavement. Prior to opening to vehicular traffic all joints shall be properly sealed and the roadway shall be cleaned. The opening of concrete pavement to vehicular traffic shall not constitute a final acceptance of the pavement. No steel blades shall be used to clean concrete surface.

517.03 Test Requirements

1. The Contractor shall provide the necessary testing of concrete for acceptance by the Town including the testing of concrete cylinders for compression testing and air and slump tests. Sample concrete test cylinders shall be made in sets of five. One cylinder shall be broken at 7 days, one cylinder at 14 days and 28 days, and two held on reserve for test if there is a failure on one of the 28 day tests. If the 28 day cylinders do not meet the specified minimum compressive strength then a representative number of concrete cores, as determined by the Engineer, shall be taken by the Contractor to determine if the in-place concrete meets the specified strength.

2. Concrete cylinders for strength tests shall be molded and cured in accordance with

the "Practice for Making and Curing Concrete Test Specimens in the Field", ASTM C31 and tested in accordance with "Test Method for Compressive Strength of Cylindrical Concrete Specimens", ASTM C39.

3. Concrete shall be tested per Table 300-11 in Section 317.02 of these Standards.

4. Mark or tag each sample of compression test cylinders with the date and time of day the cylinders were made. Identify the location in the Work where the concrete represented by the cylinders was situated or stationed. Identify the delivery truck or batch number, air content, and slump. Submit to the Town Engineer 2 copies of each test result.

5. Concrete shall meet the minimum acceptance standards of the State Specifications. Concrete that does not meet the acceptance criteria shall be removed and replaced.

6. The surface tolerance for Portland cement concrete pavement shall not be greater than 3/16 of an inch, as measured with a ten foot straight edge. For collector and arterial streets, the Town reserves the right to require a profilograph test with the specifications established by the CDOT standard specifications for the design criteria of the street.

518 STREET RESTORATION (PATCHING AND MATCHING EXISTING)

All areas to be paved must be proof rolled before pavement is constructed. Proof rolls are required on subgrade and base courses prior to placement of subsequent courses. If the area is too small for a proof roll, field density tests shall be provided.

518.01 Aggregate Base Course

Materials for aggregate base course shall conform to the requirements of Section 703.03 of the "State Specifications", Class 6 or Class 4.

518.02 Pavement Placement

1. All materials and construction techniques associated with pavement patches shall conform with the materials and construction requirements specified in these Standard Specifications for hot bituminous plant mix pavement and Portland cement concrete pavement.

2. Patching materials and construction requirements for bituminous pavement shall meet the requirements for hot plant mix bituminous pavement of this specification except as modified herein. Patching shall be for the full depth of the existing bituminous pavement in place.

3. Apply a tack coat to the contact edges of previously constructed bituminous layers, aggregate base course, Portland Cement concrete surfaces, and metal surfaces abutting or projecting into the bituminous pavement.

4. Patches for Portland cement concrete pavement shall consist of Portland cement

concrete Class ñPò To increase the load transfer and protect the pavement against differential settlement the Contractor shall drill the existing concrete pavement and provide expansion dowels in accordance with the Standard Details, minimum, distance on center at the mid-depth of the concrete. The dowels must be able to move from expansion and contraction of the concrete. To facilitate this movement, the dowels portion that protrude into the patch shall be painted and covered with a 1/16 inch coating of grease. The minimum size concrete patch allowed shall be as detailed under "Removal of Concrete Surfaces" in the general conditions.

518.03 Surfaces Tolerances

All patches shall be constructed true to grade with the existing pavement section. Variation from grade shall not exceed one-quarter (1/4) inch. If the variation exceeds one-quarter inch, the pavement and backfill shall be repaired or replaced to the satisfaction and at the option of the Town Engineer.

518.04 Temporary Patches

When weather limitations prevent the placement of pavement patches as defined herein, the Contractor shall obtain the approval of the Town Engineer to install a temporary patch of cold mix asphalt or other suitable material. As soon as conditions allow, the Contractor shall remove the temporary patch and install a permanent patch in accordance with these specifications. The Contractor shall be responsible for maintaining temporary patches in a manner satisfactory to the Town Engineer until they are replaced. In case of an emergency the Town Engineer may elect to repair the temporary patch and backcharge the Contractor for the repair of the patch.

518.05 Time Limit for Patching Street Cuts

All patches shall be made within 3 days of completing the street cut. The Town Engineer may require the patch to be made sooner if in the Townôs opinion it is a traffic hazard.

519 SIGNING, STRIPING AND STREET MARKINGS

519.01 General

This section covers materials and methods to be used for the installation of traffic control signs, lane striping, and street markings.

519.02 Quality Assurance

1. All traffic control signs shall conform to the requirements of the Manual on Uniform Traffic Control Devices (MUTCD) with regard to sign type, size, location, and mounting specifications. All signs to be approved by the Public Works department prior to installation.

2. All striping and pavement markings shall comply with the MUTCD and Section 627 of the CDOT 2002 Construction Manual, Revised 2004.
   a. Striping shall be aligned with and parallel to the roadway.
   b. Alignment shall not vary more than 2òin 100 øf roadway.

519.03 Submittals

1. Provide a CDOT Certificate of Compliance (COC) of the latex (waterborne) striping material per CDOT Standard Specifications, Section 708.05 and 708.06.

2. Provide manufacturers certification that the different types of glass beads required for latex and thermoplastic meets the requirements of CDOT Standard Specifications, Section 713.08

3. Provide manufacturers certification that all of the thermoplastic marking material meets the requirements of CDOT Standard Specifications, Section 713.12 and 713.14.

519.04 Lane Striping

1. Permanent Lane Striping Material
   a. All lane striping to be completed using latex paint and glass beads.
   b. Comply with CDOT Sections 708 and 713.17.
   c. Contactor shall not stripe until the final asphalt lift has cooled for at least 72 hours.
   d. Pavement surface shall be clean and free of soil or other debris that will prevent permanent adhesion of the epoxy to the pavement. Contractor shall use compressed air or high pressure water to remove any debris. If water is used the pavement surface shall be allowed to completely dry prior to applying paint. If deemed necessary by the Town Engineer, painting on existing pavement may require sandblasting to ñfreshenñthe surface and improve paint adhesion.
   e. Application methods shall comply with CDOT Section 627. Only an experienced applicator shall operate the equipment.
   f. Striping width shall be in conformance with the dimensions shown on the Drawings. . Application rate shall be between 100 SF/Gal (min.) and 110 SF/Gal (max.). Ambient air temperature and pavement surface temperature shall be a minimum of 40 degrees F for application.

2. Temporary Striping Material
   a. Comply with CDOT Section 713.15.
   b. Temporary striping may not be in service for more than 9 months.
   c. Temporary marking tape shall consist of conformable (metal foil) weather and traffic resistant yellow or white colored reflective material.
   d. All temporary striping material to be removed prior to subsequent covering by asphalt lift or permanent striping.

519.05 Thermoplastic Pavement Marking Material

All symbols, cross walks, stop bars, letters, etc. to be created with thermoplastic material.

1. Thermoplastic Marking Material
   a. Comply with CDOT Section 713.12.
   b. Use for STOP bars and cross walks only.
   c. Contractor shall not apply until the final asphalt lift has cooled for at least 72 hours.
   d. Pavement surface shall be clean and free of soil or other debris that will prevent permanent adhesion of the material to the pavement. Contractor shall use compressed air

or high pressure water to remove any debris. If water is used the pavement surface shall be allowed to completely dry prior to applying the material.

e. The type and application rate of epoxy resin primer shall be as recommended by the thermoplastic pavement marking manufacturer.

f. Application methods shall comply with CDOT Section 627.06. Only an experienced applicator shall operate the equipment.

g. Application width shall be in conformance with the dimensions shown on the Drawings. Material shall be applied to achieve a 3/32ònminimum thickness at the edges and 1/8ò minimum thickness in the middle. Ambient air temperature and pavement surface temperature shall be a minimum of 50 degrees F for application.

2. Preformed Thermoplastic Material

a. Comply with CDOT Section 713.14.

b. Use for all symbols, numbers, and letters.

c. Contractor shall not apply until the final asphalt lift has cooled for at least 72 hours.

d. Pavement surface shall be clean and free of soil or other debris that will prevent permanent adhesion of the material to the pavement. Contractor shall use compressed air or high pressure water to remove any debris. If water is used the pavement surface shall be allowed to completely dry prior to applying the material.

e. The type and application rate of epoxy resin primer shall be as recommended by the thermoplastic pavement marking manufacturer.

f. Application methods shall comply with CDOT Section 627.06. Only an experienced applicator shall operate the equipment.

g. Application width shall be in conformance with the dimensions shown on the Drawings. Material shall be applied to achieve a 3/32ònminimum thickness at the edges and 1/8ò minimum thickness in the middle. Ambient air temperature and pavement surface temperature shall be a minimum of 50 degrees F for application.

520 Traffic Control Signs

1. Signs shall be installed in the locations represented on the Drawings and in conformance with the MUTCD. Details for the orientation of the sign with respect to the edge of asphalt and the minimum height of the sign are included in the Drawings as well as in the MUTCD.

2. Posts shall be buried at minimum of 2ôand shall be concrete encased below grade. Posts shall be installed vertical both parallel to and perpendicular to the roadway. Post holes shall be at least twice the diameter of the posts to provide adequate concrete anchorage.

521 Traffic Impact Study Requirements

1. *Study Purpose and Site Description* - The study shall include a brief description of the development application proposal (i.e. annexation, rezoning, subdivision, site plan application etc.) It shall also include a brief description of the development proposal including the site location, the size of the land parcel, general terrain features, the types of land uses being proposed and the proposed access points.

2. *Study Area* - The boundaries of the study area will be based on engineering judgment and an understanding of existing traffic conditions surrounding the site. The limits should

be agreed upon at the pre-submittal meeting with staff. The boundaries of the study area shall be based on the size and extent of the proposed development and it's relation to significant streets and intersections. Large developments may require a study area extending beyond one mile due to the magnitude of potential impacts.

As a minimum, the study area will include:

a. Adjacent streets.
b. Adjacent arterial/arterial or arterial/collector intersections.
c. Site access points.
d. Internal roads.

A vicinity map that shows the site and the study area boundaries in relation to the surrounding transportation system must be included in the study. All arterial and collector streets in the study area and access points to the site should be shown on the map.

Key intersections in the study area that will be analyzed in the study shall be identified at the pre-submittal meeting. The key intersections should be identified on the map.

3. Study Horizons - Three study horizons are required for analysis: The current conditions, short term and long term.

The current (existing) conditions should be analyzed to establish a baseline of traffic conditions.

The short-term horizon represents the planned opening year of the project. Both a background analysis and analysis with the project completed should be completed to assess the short-term impacts of the project. Assumptions about street improvements not associated with the study project in the short term should be based on projects shown in the Town of Frederick's Comprehensive Plan (FCP) or projects that have already been financially obligated to a developer.

The long term planning horizon represents conditions 20 years out. The Town of Frederickôs Planning Area is shown in the Townôs Comprehensive Plan (FCP). For land uses in compliance with the FCP this analysis should be completed using the information as shown in the FCP. For land uses that are not in compliance with the FCP analyses for both the adopted land uses in the FCP and the proposed land uses should be completed so that the impact of the land use change can be evaluated.

When an overall traffic impact study is completed for a phased development the study shall look at all three study horizons. Addenda for each phase of development should only look at the current conditions and the short-term horizon.

4. Analysis Time Periods - Normally, the analysis time periods will be the weekday a.m. and p.m. peak hours. Under some circumstances the Town may require analyses to occur at other times as appropriate.

5. Existing/Base Conditions
   a. Existing and Proposed Land Uses - A complete description (including a map) of

the existing land uses in the study area as well as their current zoning, shall be included in the study. In addition, the future uses of all vacant land within the study area that may be developed within the projection year of the project must be identified. For the short term horizon only land where development applications have been approved should be considered as developed within the projection year. For the long-term horizon, land uses shown in the FCP should be assumed as developed within the projection year.

b. Existing and Proposed Transportation System - The study shall describe the existing roadways and intersections in the study area including the road geometry and intersection traffic control. For the short-term horizon, assumptions about road improvements not related to the development shall be based on the improvements already financially obligated to a developer. For the long-term horizon all improvements shown in the FCP within the study area should be assumed.

c. Existing Traffic - Current a.m. and p.m. peak hour traffic volumes shall be obtained for the roadways and intersections within the study area. "Current" means counts less than a year old. A map or series of maps of the existing roadway network shall be prepared showing the existing conditions and volume counts including lane geometry, traffic control, access points, turning movement volumes, and calculated peak hour factors.

d. Background Traffic - For the short term horizon, background traffic shall be the sum of existing traffic volumes plus the addition of traffic from any not yet built but approved developments in the study area plus background traffic growth. The annual percentage of background traffic growth should be agreed upon at the pre-submittal meeting.

For the long-term horizon, background traffic shall be based on the most recent traffic forecasts. Maps of both the short term and long term roadway network shall be prepared showing the projected conditions and projected volume counts including lane geometry, traffic control, access points, a.m. and p.m. peak hour turning movement volumes and calculated peak hour factors.

6. Site Related Traffic

a. Trip Generation - A summary table listing each type of land use, the size or amount involved, the trip generation rates used and the resultant total trips must be provided. Trip generation rates shall be calculated using data contained in the latest edition of the Institute of Transportation Engineersô(ITE) Trip Generation Manual or from a local trip generation study following procedures prescribed in the ITE Trip Generation Manual. If a local trip generation study is used to determine the trip generation rate, documentation of the trip generation study and the resulting rate should be included in an appendix of the traffic impact study.

The ITE Trip Generation Manual presents data on trip generation rates in various formats. A weighted average trip generation rate is shown. Also, when possible, a regression equation is presented that defines the line representing ñbest fitòof the data. Trip generation rates should be determined as outlined below.

Use Regression Equation When:

1. A regression equation is provided.
2. The independent variable is within range of data and either the data plot has at

least 20 points.

3. Or the R_2 is greater than or equal to 0.75, equation falls within the data cluster in the plot and the standard deviation is greater than 110% of the weighted average rate.

Use the Weighted Average Rate When:

1. At least three data points.
2. Independent variable is within range of data.
3. Standard deviation is less than or equal to 110% of the weighted average rate.
4. R_2 is less than 0.75 or no equation provided.
5. Weighted average rate falls within data cluster plot.

Collect Local Data When:

1. Study site is not compatible with ITE land use code definition.
2. Only 1 or 2 data points; preferably when five or fewer data points.
3. Independent variable does not fall within range of data.
4. Neither weighted average rate line or fitted curve fall within data cluster at size of development.

Trip making reduction factors may be used after first generating trips at full ITE rates. These factors fall into two categories: those that reassign some portion of generated trips to the background stream of traffic, and those that remove or move generated trips. In all cases, the underlying assumptions of the ITE Trip

Generation rates must be recognized and considered before any reductions are claimed.

The first category is when trips to the proposed development currently exist as part of the background traffic stream, referred to as pass-by trips. Pass-by percentages identified by ITE or in other industry publications may typically be used. But, the source of the percentages must be identified and the Town must approve use. Pass-by traffic must continue to be assigned to site driveways and access points, but is not additive to the background traffic stream. An appendix that illustrates the assignment of pass-by trips must be included in the report.

The second category for adjustments is for internal site trips, transit use, and transportation demand management (TDM) actions. Reductions of these types may be allowed if analytic support is provided to show how the figures were derived. The Town must approve any reductions that are claimed. Optimistic assumptions regarding transit use and TDM actions will not be accepted unless accompanied by specific implementation proposals that will become a condition of development approval. Such implementation proposals must have a high expectation of realization within a 3-year period after project initiation.

b. Trip Distribution - The percentage of trips to/from the proposed development to/from destinations in the region must be clearly shown graphically in the report. The consultant shall be responsible for estimating trip distribution. Marketing studies, sub-area transportation studies, documented existing traffic patterns and professional judgment may be used to make trip distribution assumptions. Whatever method(s) are used, the procedures and rationale used should be fully

explained and documented in the study.

Different trip distribution assumptions can be used for different land uses in mixed-use developments. If more than one set of distribution assumptions are made they should be shown on separate graphics.

c. Trip Assignment - Site generated traffic shall be assigned to the street system according to the trip distribution percentages determined in the previous step. The traffic assignment must be clearly shown graphically in the report.

7. Analysis and Identification of Impacts

a. The project impacts shall be determined through an analysis procedure that follows the sequence of tasks outlined below.
   1. Assessment of existing conditions.
   2. Assessment of short term background conditions.
   3. Assessment of short term conditions with the planned land use shown in the FCP for the land being proposed for development (only needed when the proposed development is requesting a land use amendment).
   4. Assessment of short term conditions with the proposed development.
   5. Assessment of long term background conditions.
   6. Assessment of the long term conditions with the proposed development when a land use amendment is being requested.

b. Highway Capacity Analysis - Assessment techniques for existing conditions, short term background and short term with the development will include a capacity and level of service (LOS) analysis for the key intersections identified in the study area during the identified analysis time periods. For signalized intersections the analyses shall be completed using the operational analysis methodology shown in the latest edition of the Highway Capacity Manual published by the Transportation Research Board. Both volume to capacity ratio (v/c ratio) and level of service for each movement shall be reported in a table or diagram for each signalized intersection analyzed. The overall intersection level of service shall also be reported. The Town's goal for traffic congestion states that all signalized intersections should be maintained at overall LOS D or better. In addition, the goal requires that all movements that have 5% or more of the total entering intersection volume should be maintained at LOS D or better and have a volume to capacity ratio less than 1.0. Therefore, any signalized intersections or movements at signalized intersections that exceed these thresholds should be noted.
   The capacity and level of service analysis at signalized intersections shall be performed using the following assumptions:
   1. Peak hour factors should be calculated on an approach by approach basis from the turning movement count data collected for the analysis.
   2. Right turns on red should not be considered unless specific data documenting the percentage of turns on red is collected.

   3. Unless approved by the Town at the pre-submittal meeting all arrival types shall be assumed to be type 3 as defined in the Highway Capacity Manual.

4. Signal controller unit extension should be assumed to be 3.0 for through movements and 2.0 for left turn movements.
5. Start up lost time should be assumed to be 2.0 seconds unless otherwise approved by the Town.
6. Extension of effective green should be assumed to be 3.0 seconds unless otherwise approved by the Town.
7. Traffic signal timing parameters for the existing conditions will be the actual signal timing in effect unless determined otherwise by the Town. Traffic signal timing parameters for the short term background conditions and the short term conditions with the development will use signal cycle lengths between 80 and 120 seconds. Cycle lengths and Individual green intervals will be calculated to provide the least overall intersection delay while maintaining all movements below the congestion goal thresholds whenever possible. Clearance intervals shall be the actual times currently in effect for all scenarios analyzed. Where different signal phasing from the existing is used for the analysis this change shall be noted in the list of traffic impacts. Where traffic signals are part of a coordinated signal system or where proposed new signals are within a half mile of another signal the cycle lengths used for analysis should be the same at all intersections analyzed.
8. Saturation flow rate will be assumed to be 1900 pcphgpl.
9. Lane widths should be assumed to be 12 feet wide unless other data shows otherwise.
10. Percent of trucks should be determined by observation for all movements unless approved otherwise by the Town.
11. Saturation flow adjustment factors should be as per the Highway Capacity Manual.
12. Where dual left turns exist or are proposed they shall be assumed to operate in a protected only mode.
13. Free running right turns that are not effected by the signal timing should be excluded from the analysis.

Level of service analysis for unsignalized intersections shall be done in accordance with the methodology for unsignalized intersections in the latest edition of the Highway Capacity Manual. The results of the unsignalized intersection analysis should be shown in the table or diagram used for signalized intersection results. The following assumptions should be used for the analysis of unsignalized intersections:

1. Duration of analysis period is assumed to be .25 hour.
2. Peak hour factors should be calculated on an approach by approach basis from the turning movement count data collected for the analysis.
3. Percent of trucks should be determined by observation for all movements unless approved otherwise by the Town.
4. Saturation flow rate will be assumed to be 1700 pcphgpl.
5. Critical gap and follow up time shall be in accordance with the values given in the Highway Capacity Manual.

Assessment techniques for both long term background and long term with the proposed development will require analysis using the planning methodology for signalized intersections and the unsignalized intersection methodology for unsignalized

intersections as outlined in the latest edition of the Highway Capacity Manual. The condition (i.e. under capacity, near capacity, over capacity etc.) for signalized intersections and the level of service for unsignalized intersections should be reported in a table or diagram.

The following assumptions shall be used for the long-range signalized intersection analysis.

1. A peak hour factor of 0.9 shall be used.
2. Cycle lengths between 80 and 120 seconds shall be used.

Assumptions for the long-range unsignalized intersection analysis shall be the same as for the short-term analysis.

c. Access Evaluation - Assessment techniques for existing conditions, short term background, short term with the development, long term background and long term with the development will also include an evaluation of each proposed access point. Accesses should be considered intersections and included in the level of service/capacity analysis described above.

   Safety is the top priority at access points. The Town has developed standards for the spacing and design of access points to provide optimum safety. Accesses should be reviewed to ensure compliance with Town (and CDOT if on a State Highway) standards. Proposed access points that do not meet the pertinent standards should be noted. In addition, all access points should be evaluated to determine what auxiliary lanes are required in accordance with Town standards and the State Highway Access Code (where applicable).

d. Evaluation of Signal Progression in Coordinated Signal Systems ï According to City Standards, intersections with the potential for signalization should be spaced no closer than one half mile. If a development proposes an access or intersection that is projected to be signalized and is less than a half mile from other signals or other planned signals a progression analysis shall be conducted to demonstrate that a new signal can be installed without negatively impacting progression.

   The analysis shall consider all existing signals or possible future signals within one mile in each direction from the proposed signal location. On existing coordinated arterials, it must be demonstrated that the existing bandwidth in each direction can be maintained with the new signal installed. Where a new coordinated system will occur as a result of the new signal it must be demonstrated that a bandwidth of at least 45% can be achieved in each direction unless otherwise directed by the Town. The following assumptions shall be used for the progression analysis:

   1. A cycle length between 80 and 120 seconds should be used for analysis.
   2. Actual prevailing speeds on the arterial shall be used for travel speed.
   3. Split assumptions shall be based on projected turning movement volumes and designed to maintain all movements with at least 5% or more of the total intersection traffic at LOS D or better and below v/c ratio of 1.0 in keeping with the Town of Frederick Congestion Goal. Where pedestrian volumes are expected to be high (to be determined in the pre-submittal

meeting), side street splits long enough to accommodate pedestrians shall be used assuming a 4.0 fps walking speed.

4. Where left turn arrows are anticipated, protected/permissive phasing should be assumed unless dual left turns are projected. Then, protected only left turn phasing should be assumed.
5. Lagging left turns will not be allowed for protected left turn phases.

Any access where the required bandwidth cannot be achieved should be noted. Any such access shall remain unsignalized and have turning movements limited by driveway design and/or median islands to prevent the need for signalization. Time-space diagrams shall be included in an appendix to the study.

e. Other analysis required on a case by case basis ï Where the Town deems it appropriate, other types of analysis may be required in the traffic impact study. Other types of analysis may include but are not limited to: Sight distance evaluation, transit and TDM opportunities, pedestrian/bicycle needs, environmental evaluations and evaluation of neighborhood impacts.

522 STREET LIGHTING STANDARDS

1. Street lighting and associated underground street lighting supply circuits shall be installed. Roadway lighting shall conform to the illuminance or luminance design values shown in Table 3-5a of the AASHTO Roadway Lighting Design Guide, 2005, which has been reproduced in part below. These values are for continuous lighting. Conflict lighting at intersections shall be twice these values. A photometric study drawing is required to be included with the construction plans for all subdivisions.

Illuminance Method				
		Average Maintained Illuminance	Minimum Illuminance	Illuminance Uniformity Ratio
		Asphalt Road Surface (typical) foot-candles (min)	foot-candles	avg/min (max)
Arterials	Commercial	1.4	As uniformity ratio allows	4:1
	Intermediate	1.0		4:1
	Residential	0.7		4:1
Collectors	Commercial	1.1		4:1
	Intermediate	0.8		4:1
	Residential	0.6		4:1
Local	Commercial	0.8		6:1
	Intermediate	0.7		6:1
	Residential	0.4		6:1

2. Types of allowed light poles and fixtures. Unless otherwise approved by the Town Engineer, all light poles shall be of types indicated in the approved materials list in Appendix 1. Roadway lighting shall be mounted with poles of either 15 or 30 feet, as approved by the Town Engineer, corresponding to a luminaire height of either 15 or 30 feet. The height of the roadway lighting shall conform to the general character of the

development. The height of the roadway lighting shall be chosen while considering possible luminaire wattages from 70 to 250 watts, such that the illuminance levels (shown in the above table) or luminance levels (shown in Table 3-5a of the AASHTO Roadway Lighting Design Guide, 2005) are provided.

3. Pedestrian lighting. At a minimum, pedestrian lighting shall be provided at intersections of pedestrian trails and at intersections of trails with roadways. Such lighting shall be of a type and character that provides for both pedestrian safety and aesthetic conformance to the adjacent development.

4. Height standards for lighting. Light fixtures, other than street lighting, shall be mounted on poles no higher than the maximum height for structures allowed in that zone district, unless a different height is approved by the Town Engineer. Lighting mounted on a building or structure shall not exceed the height of the building or structure. Bollard-type lighting fixtures shall be between three (3) and four (4) feet high, unless otherwise approved by the Town Engineer.

523 References

Standards Referenced in Section 500:	
Standard	**Title**
AASHTO M145	Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, Single User Digital Publication
AASHTO T27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T89	Standard Method of Test for Determining the Liquid Limit of Soils
AASHTO T90	Determining the Plastic Limit and Plasticity Index of Soils, Single User Digital Publication
AASHTO T164	Standard Method of Test for Quantitative Extraction of Asphalt Binder from Hot-Mix Asphalt (HMA)
AASHTO T180	Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T190	Standard Method of Test for Resistance R-Value and Expansion Pressure of Compacted Soils
AASHTO T206	Standard Method of Test for Penetration Test and Split-Barrel Sampling of Soils
AASHTO T230	Standard Method of Test for Laboratory Determination of Moisture Content of Soils
AASHTO T265	Standard Method of Test for Laboratory Determination of Moisture Content of Soils
AASHTO T290	Standard Method of Test for Determining Water-Soluble Sulfate Ion Content in Soil
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort
ASTM D2950	Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4546	Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods
CP 44	Bulk Specific Gravity and Percent Relative Compaction of Compacted Bituminous Mixtures Using Saturated Surface-Dry
CP 48	Determination of the Voids in the Mineral Aggregate (VMA)
CP 51	Determining the Maximum Specific Gravity of HMA
CP 81	Density and Percent Relative Compaction of In-Place Bituminous Pavement by the Nuclear Method
CP 82	Field Correction of the In-Place Measurement of Density of Bituminous Pavement by the Nuclear Method
FHWA-RD-00-067	Roundabouts: An Informational Guide